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IMAGE PROCESSING METHOD

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[There are no amendments to this patent.]

Abstract

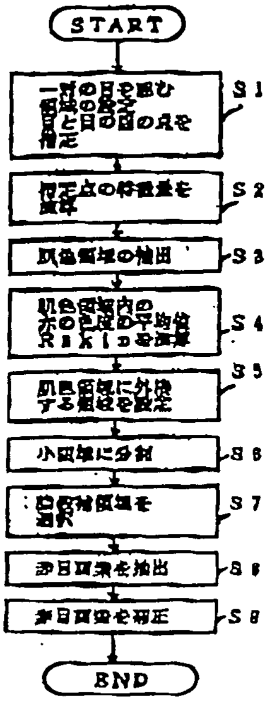
Problem

To easily and accurately correct for red-eye in flash photography.

Solution

The designation of areas surrounding a pair of eyes and the specification of a point between the eyes are carried out (S1), the characteristic quantity of the color at the specified point is calculated (S2), a skin color area is extracted from the designated area (S3), an average value of the chromaticity of the red color within the skin color area is calculated (S4), an area circumscribing the skin color area is designated (S5), this designated area is further divided into small areas (S6), pupil

candidate areas are selected from the small areas (S7), red-eye pixels in the pupil candidate areas are extracted (S8) in order to correct said red-eye pixels (S9).



Key:	S1	Designation of an area surrounding a pair of eyes. A point between the eyes is specified.
	S2	Characteristic quantity of the color at the specified point is calculated.
	S3	Extraction of skin color areas.
	S4	Calculation of the average value (Rskin) of the chromaticity of the red color in the skin color area.
	S5	An area circumscribing the skin color area is designated.
	S6	Division into small areas.

S7 Pupil candidate areas are selected from the small areas.
S8 Red-eye pixels within the pupil candidate areas are extracted.
S9 Red-eye pixels are corrected.

Claims

1. Image processing method characterized in that an area which may contain 1 or more poor color tones in the pupils is designated in a photo image which contains pupils in the subject,

the aforementioned designated area is divided into small areas,

small areas with a high possibility of containing pupils with poor color tones are selected as pupil candidate areas based on color data and positional data of the aforementioned small areas,

pixels with poor color tones are extracted from the aforementioned selected pupil candidate areas, and

the aforementioned extracted pixels are corrected for poor color tones.

2. Image processing method described in Claim 1 and characterized in that an area surrounding a pair of pupils is designated for the aforementioned area possibly containing pupils with poor color tones, the center point of said designated area is calculated, and the division into small areas and the selection of pupil candidate areas are carried out based on color data and positional data using said center point as a reference.

3. Image processing method described in Claim 1 and characterized in that the aforementioned designation of the area surrounding the pair of pupils is done by specifying a point near the center between the pupils and by designating an area of a

prescribed area around said specified point, and the division into small areas and the selection of the pupil candidate areas are carried out based on color data and positional data using the aforementioned specified point as a reference.

4. Image processing method described in Claim 1 and characterized in that to designate the aforementioned area where poor color tones may be present in the pupils, an area surrounding a pair of pupils where 1 or more poor color tones may be present is designated, a point near the center between the pupils is specified, and the division into small areas and the selection of pupil candidate areas are carried out based on color data and positional data using said center point as a reference.

5. Image processing method described in one of Claims 1 through 4 and characterized in that the aforementioned division into small areas is done by extracting edge pixels from the aforementioned designated area based on color data and by dividing the designated area into areas surrounded by said edge pixels.

6. Image processing method described in one of Claims 1 through 5 and characterized in that the aforementioned selection of pupil candidate areas is done by using evaluation functions indicating pupil probability based on color data and positional data after 2 of the aforementioned small areas are combined into 1, respectively, and by selecting the combination which shows the highest value.

7. Image processing method described in one of Claims 1 through 6 and characterized in that the aforementioned correction to the pixels with poor color tones is carried out based on the brightness data for the color elements other than red contained in the pixels with poor color tones.

8. Image processing method described in one of Claims 1 through 7 and characterized in that the aforementioned correction of pixels with poor color tones is carried out based on the data for the colors selected by the operator from multiple color samples.

9. Image processing method described in one of Claims 1 through 8 and characterized in that to carry out the aforementioned correction of pixels with poor color tones, the range of the corrections of pixels with poor color tones is made adjustable for the operator through the arbitrary setting of the threshold with regard to color data for the extraction of pixels with poor color tones.

Detailed explanation of the invention

[0001]

Technical field of the invention

The present invention pertains to an image processing method for the correction of poor color tones in pupils in a subject image due to the emission of a flash in color photography.

[0002]

Prior art

Several techniques for correcting the aforementioned poor color tones, so-called red-eye, have been suggested (Refer to U.S. Patent No. 5130789, Japanese Kokai Patent Application No.

Hei 7[1995]-72537, etc.). In the technique disclosed in U.S. Patent No. 5130789, a target area around the eyes is surrounded by a rectangular mask, several points in red-eye areas are specified using a pointer, the red-eye areas are designated based on color data, and corrections are made once the target pixels are determined to possibly cause red-eye. At that time, the correction amount is altered according to the distance of the area from the edge.

[0003]

Also, in the technique disclosed in Japanese Kokai Patent Application No. Hei 7[1995]-72537, a target eye area is designated, and after candidate pixels are selected based on color data and labeled, whether they cause red-eye or not is determined by considering data from respective labels. In addition, in terms of the correction method, corrections are made at different rates to the main part of the red-eye and to the surrounding part.

[0004]

Problems to be solved by the invention

With respect to the technique in U.S. Patent No. 5130789, a burden is imposed on the operator in that several points must be specified in the red-eye areas in addition to surrounding the target areas around the eyes with the rectangular mask. With respect to the technique in Japanese Kokai Patent Application No. Hei 7[1995]-72537, although the candidate areas are designated through the comparison of multiple color data with the threshold, because the color data, particularly for the areas surrounding the red-eye, differ significantly according to the differences in terms of the photographic scene and the individuals, it is difficult to use the same conditions for setting, causing lower efficiency. Also, the correction method is complicated in that main parts must be separated from surrounding areas to which corrections are made at different rates.

[0005]

The present invention was made considering these conventional problems, and its purpose is to present an image processing method by which red-eye correction can be done easily and accurately.

[0006]

Means to solve the problems

To this end, as shown in the block diagram in Figure 1, the invention in Claim 1 is characterized in that an area which may contain 1 or more poor color tones in the pupils is designated in a photo image which contains pupils in the subject, the aforementioned designated area is divided into small areas, small areas with a high possibility of containing pupils with poor color tones are selected as pupil candidate areas based on color data and positional data of the aforementioned small areas, pixels with poor color tones are extracted from the aforementioned selected pupil candidate areas, and the aforementioned extracted pixels are corrected for poor color tones.

[0007]

Also, the invention in Claim 2 is characterized in that an area surrounding a pair of pupils is designated for the aforementioned area possibly containing pupils with poor color tones, the center point of said designated area is calculated, and the division into small areas and the selection of pupil candidate areas are carried out based on color data and positional data using said center point as a reference.

[0008]

Also, the invention in Claim 3 is characterized in that the aforementioned designation of the area surrounding the pair of pupils is done by specifying a point near the center between the pupils and by designating a prescribed area around said specified point, and the division into small areas and the selection of the pupil candidate areas are carried out based on color data and positional data using the aforementioned specified point as a reference.

[0009]

Also, the invention in Claim 4 is characterized in that to designate the aforementioned area where poor color tones may be present in the pupils, an area surrounding a pair of pupils where 1 or more poor color tones may be present is designated, a point near the center between the pupils is specified, and the division into small areas and the selection of pupil candidate areas are carried out based on color data and positional data using said center point as a reference.

[0010]

Also, the invention in Claim 5 is characterized in that the aforementioned division into small areas is done by extracting edge pixels from the aforementioned designated area based on color data and by dividing the designated area into areas surrounded by said edge pixels. Also, the invention in Claim 6 is characterized in that the aforementioned selection of pupil candidate areas is done by using evaluation functions indicating pupil probability based on color data and positional data after 2 of the aforementioned small areas are combined into 1, respectively, and by selecting the combination which shows the highest value of all.

[0011]

Also, the invention in Claim 7 is characterized in that the aforementioned correction of the pixels with poor color tones is carried out based on the brightness data for the color elements other than red contained in the pixels with poor color tones. Also, the invention in Claim 8 is characterized in that the aforementioned correction of the pixels with poor color tones is carried out based on the color data selected by the operator from multiple color samples.

[0012]

Also, the invention in Claim 9 is characterized in that to carry out the aforementioned correction of the pixels with poor color tones, the range of corrections for the pixels with poor color tones is made adjustable for the operator through arbitrary setting of a threshold with regard to the color data for the extraction of pixels with poor color tones.

[0013]

Effect of the invention

With the invention pertaining to Claim 1, because the pupil candidate areas can be selected highly accurately from the respective small areas obtained by dividing the area possibly containing pupils with 1 or more poor color tones, red-eye can be corrected accurately and pixels with poor color tones in the pupil candidate areas can be corrected.

[0014]

Also, with the invention pertaining to Claims 2 through 4, the pupil candidate areas can be selected highly accurately with a minimum burden on the operator. Also, with the invention pertaining to Claim 5, because the division into small areas with almost the same color tone base can be achieved by dividing the target area into areas surrounded by the edge pixels, extraction of the pixels with poor color tones from the small areas becomes easier.

[0015]

Also, with the invention pertaining to Claim 6, because evaluations are made on combined sets respectively comprising 2 small areas, pupil candidate areas can be selected highly accurately by means of evaluation functions utilizing symmetry, especially when red-eye is present in both pupils. Also, with the invention pertaining to Claim 7, based on the brightness data for color elements other than red, for example, blue and green, brightness of red or of red, blue, and green can be matched with the quality of said brightness in order to correct for a natural look.

[0016]

Also, with the invention pertaining to Claim 8, the operator can make corrections in order to obtain desired colors by making selections from color samples. Also, with the invention pertaining to Claim 9, because the threshold is provided, the operator can expand or reduce the areas to be corrected according to the degree of poor color tone as determined by the operator; variations in the color data, for the areas with poor color tones and the surrounding areas due to the differences in terms of the photographic scene and the individuals, can be absorbed.

[0017]

Embodiments of the invention

Embodiments of the present invention will be explained below with reference to figures. Figure 2 shows the system configuration of an embodiment. Digital image data for a color image captured through a still video camera or digital image data read using a scanner from a color image captured through a silver halide camera and printed paper and developed on a film are stored in a memory unit (1) such as an optical disk.

[0018]

The image data stored in the aforementioned memory unit (1) are read by a control unit (2), and an image is displayed on a monitor (3). While looking at the image displayed on the aforementioned monitor, the operator designates image areas where red-eye due to flash photography is present in the subject image in the following manner in order for the aforementioned control unit (2) to extract the pixels causing red-eye from said areas, make corrections, and display the corrected image on the monitor (3).

[0019]

The red-eye correction routine pertaining to the present invention will be explained below with reference to the flow charts in Figure 3 and following. Figure 3 shows the red-eye correction routine. In Step 1 (indicated by S in the figure and following), a rectangular area surrounding a pair of eyes is designated in the subject image containing the pupils and displayed on the monitor (2), and a point near the center between the pair of eyes is specified as a reference point for color data and positional data to be described later (refer to Figure 6).

[0020]

As the method for setting the aforementioned target area and the center point, both the target area and the center point may be specified by the operator; or only the target area is designated and the center point is then calculated (for example, the center of the designated rectangular area is calculated as the center point); or, only the center point is specified, and a prescribed area around said point may be taken as the target area. For typical red-eye correction, the first method is most suitable for manually carrying out the designation of the target area and the specification of the center point.

[0021]

The characteristic of the present invention is that an area surrounding the pair of pupils is designated, for example, even when only 1 pupil of the pair of pupils contains poor color tones. In addition, when both pupils have the red-eye effect, 2 red-eye effects can be corrected simultaneously with only one designation of the area. For example, in the technique disclosed in aforementioned U.S. Patent No. 5130789, because the area designation is carried out for each pupil, the operator's involvement is increased.

[0022]

In Step 2, color data, for example, the total value (R + G + B) of the respective values of the brightness of R (red), G (green), and B (blue), at the point specified in aforementioned Step 1 are calculated as the characteristic quantity. In Step 3, those pixels with a characteristic quantity different from the characteristic quantity at the aforementioned specified point only within a prescribed threshold are determined as skin color pixels, and an area containing said skin color pixels is extracted. That is, because the aforementioned specified point, the point near the center between the eyes, is located at the base of the nose, the color at said point is assumed to be skin color, so that an area with a color close to the color at said point can be assumed to contain pixels with the skin color. In addition, hue and chroma, which are general color data, may be used as characteristic quantities. In this way, the pixels which fall under the aforementioned threshold are labeled, and the labeled area containing the specified point is extracted as a skin color area.

[0023]

In Step 4, an average value (Rskin) of the chromaticity (= R/(R + G + B)) of the red color in the aforementioned skin color area is obtained. In Step 5, in order to reduce the amount of the following calculation and the amount of the data necessary for said calculation, a rectangular area (an area with long sides containing the point between the eyes and circumscribing both eyes simultaneously) circumscribing the skin color area extracted in aforementioned Step 3 is designated as a new target area. The designation of said rectangular area is done automatically. Although it may be done manually, if it is done automatically, a situation in which the operator designates a large area containing areas other than the face can also be dealt with.

[0024]

In Step 6, the aforementioned target area is divided into small areas. The subroutine for said division into small areas will be explained according to the flow chart in Figure 4. In Step 11, edge pixels are obtained which are within the aforementioned designated area. As for the method for obtaining the edge pixels, the sum of the absolute values of the differences in brightness between the target pixels and the respective surrounding 4 pixels is obtained using the brightness (R + G + B), for example, as the characteristic quantity; and if said sum is equal to or greater than the prescribed threshold, the target pixels are determined to be edge pixels. In addition, an edge detection filter, such as a Sobel operator, Prewitt operator, and etc., may be utilized.

[0025]

In Step 12, the edge pixels detected in aforementioned Step 11 are labeled. In Step 13, the pixel surrounded on at least 3 sides by edge pixels is changed to the same label as that of the aforementioned edge pixels. In other words, the area surrounded by the edge pixels adopt the same label. In this way, the designated area is divided into small areas with the same labels.

[0026]

Returning to the main routine in Figure 3, in Step 7, an area with a high probability of containing pupils with poor color tones is selected as a pupil candidate areas from the aforementioned divided small areas. The subroutine for the aforementioned selection of pupil candidate areas in Step 7 will be explained with reference to the flow chart in Figure 5.

[0027]

In the present embodiment, 2 of the aforementioned divided small areas are combined into 1, respectively, and pupil probability is obtained through the calculation of the following characteristic quantity for all combinations. In Step 21, chromaticity (= R/(R + G + B)) of the red color in respective small areas is obtained, and the maximum value (Ri) of the chromaticity of the red color over the areas and the position (Xi, Yi) of the pixel with the aforementioned maximum value (Ri) on the X and Y axes when the point near the center between the eyes specified in aforementioned Step 1 is used as the origin are used to indicate the characteristic quantity. Here, i represents a value for the identification of the small area.

[0028]

For example, when combining small areas (1) and (2), a pupil candidate area is selected in the following manner. In Step 22, characteristic quantity of color data (C12) and characteristic quantity of positional data (P12) are obtained using the following equations.

Characteristic quantity of color data (C12) = R1 + R2

Characteristic quantity of positional data

(P12) = X1 + X2 + Y1 + Y2

Here, a greater characteristic quantity of color data and a smaller characteristic quantity of positional data means a higher pupil probability. Thus, in Step 23, the characteristic quantity (E12) indicating the pupil probability is set as E12 = C12 - P12, for example, and the combination of small areas highest in said value is extracted as a pupil candidate area with a high possibility of containing at least one pupil area with poor color tones.

[0029]

Here, the reason why the smaller the characteristic quantity of the positional data is, the higher the pupil probability becomes is that when red-eye is present in both eyes, the value becomes smaller because the calculation is based on X1, either the left or the right side across the point between the eyes is treated as + and X2 on the other side is treated as -. Also, the reason why the case in which only one pupil contains red-eye can be handled is that when the combination of both pupils is selected, the values of the positional data (P12) become smaller even when one pupil does not contain red-eye. Also, even when only one pupil has red-eye, the characteristic quantity of the color data is greater in comparison to a combination without red-eye.

[0030]

Returning to the main routine in Figure 3, in Step 8, pixels with poor color tones (red-eye) are extracted from the pupil candidate areas extracted in Step 7. The pupil extraction method is as follows. If the chromaticity (= R/(R + G + B)) of the red color of the target pixels is greater than the average value (Rskin) of the skin color area obtained in Step 2, and it is also greater than the value obtained by subtracting the preset threshold (TH) from the characteristic quantity (Ri) of the color data on the target area, they are determined to be red-eye pixels. In other words, the pixels which meet the following equation are considered to be red-eye pixels.

[0031]

$$R/(R + G + B) > Rskin \cap R/(R + G + B) > Ri - TH$$

In Step 9, the red-eye pixels extracted in Step 8 are corrected to achieve appropriate colors. In this case, because a very unnatural look will result if the pixels are all corrected to have the same pixel value, brightness data other than for the color red is utilized. For example, when the digital values of R, G, and B are R = 200, G = 50, and B = 30, respectively, correction is made with a gray color which matches the lowest value of the digital values. In this case, because the correction can be made to achieve a pupil image which reflects the brightness of R = G = B = 30 to some extent, a natural look will be obtained.

[0032]

Otherwise, in order to handle the case in which the original color of the pupils is not gray, the values of G and B are kept constant when the digital values of R, G, and B are R = 200, G = 50, and B = 30, respectively, as in the aforementioned case, and R is matched with the larger value of G and B, for example, G of 50, in this case. In addition, the value of R may be matched with the average value of G and B, that is, 40, in this case.

[0033]

Furthermore, if the color of the pupils do not match the color of the operator's preference, a desired color is selected from a color pallet (samples) for the pupil, and corrections are made based on this color data. As for the correction method, for example, the following procedures are followed. Color data, YIQ, for example, for the selected color are obtained by the following equation.

[0034]

No. 1

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.3 & 0.59 & 0.11 \\ 0.6 & -0.28 & -0.32 \\ 0.21 & -0.52 & 0.31 \end{bmatrix} \cdot \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

[0035]

The maximum value of B + G for the red-eye pixels is obtained and indicated as Lmax. Brightness (Y) of the pallet is multiplied by the value obtained by dividing L (= B + G) of the target pixels by Lmax (refer to the following equation).

$Y' = Y \times L/Lmax$

While keeping the values of I and Q, reverse conversion into R, G, and B is carried out to determine said digital value as a correction value. A more natural look can be achieved in this way.

[0036]

In other words, although the pallet is used select the color, because the corrections are made using the brightness data for the elements other than the red-eye pixels, a natural look can also be obtained. Although the chromaticity of the red color was obtained over a series of processing, combination of other general color data, such as brightness, hue, chroma, and so forth, may be used. The present embodiment offers the following effects.

[0037]

① Little involvement of the operator is needed.

② Because edge data are utilized for the division of area, in comparison to the method in which color data alone are utilized for the division, influence by the differences in terms of the photographic scene and the individuals is unlikely to occur, and correction can be made at high efficiency.

③ Cases in which those other than Japanese people are involved where the color of the aforementioned pupils is not gray can also be dealt with by making the aforementioned corrections.

[0038]

Next, a second embodiment will be explained. In the aforementioned first embodiment, there are cases in which only a portion of the red-eye part to be corrected may be corrected due to the differences in red-eye parts among individuals, or the parts where red-eye is not present are also corrected. In the present embodiment, in order to prevent this problem, the operator adjusts the threshold for determining whether corrections are needed or not while looking at an image, so that a correction area can be adjusted.

[0039]

More specifically, if the operator determines that only a portion of a red-eye part is corrected when looking at the image, the value of the aforementioned threshold (TH) set for the detection of red-eye pixels is lowered repeatedly until the correction area is enlarged to an appropriate area. On the other hand, if the operator determines that the parts where red-eye is not present are also corrected, the value of the aforementioned threshold (TH) is increased repeatedly until the correction area is reduced to an appropriate area.

[0040]

Designation of a red-eye area is partially dependent upon subjectivity, so that by doing it this way, correction which would satisfy the operator's subjectivity can be made. Also, variations in the color data for the red-eye areas and the surrounding areas due to the differences in terms of the photographic scene and the individuals can be absorbed.

Brief description of the figures

Figure 1 is a block diagram showing the configuration/function of the present invention.

Figure 2 is a diagram showing the system configuration of an embodiment.

Figure 3 is a flow chart showing the main routine for the red-eye correction in the above embodiment.

Figure 4 is a flow chart showing the subroutine for the division into small areas under the above routine.

Figure 5 a flow chart showing the subroutine for the selection of pupil candidate areas under the above routine.

Figure 6 is a diagram showing the target area designation method in the above embodiment.

Symbols

1 Memory unit
2 Control unit
3 Monitor

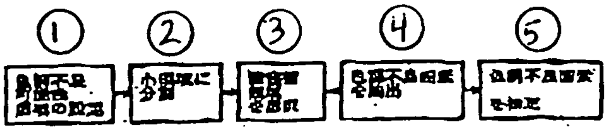


Figure 1

Key: 1 Designation of area possibly containing poor color tones
2 Division into small areas
3 Designation of pupil candidate areas
4 Extraction of pixels with poor color tones
5 Correction of pixels with poor color tones

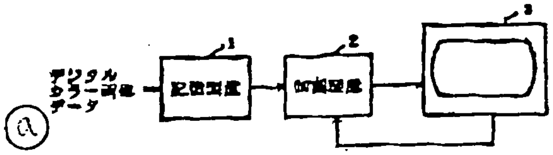


Figure 2

Key: a Digital color image data
1 Memory unit
2 Control unit

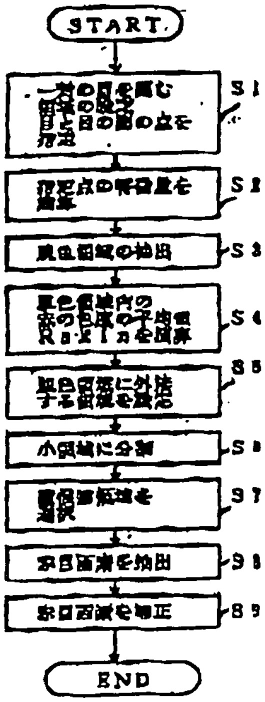


Figure 3

Key:	S1	Designation of an area surrounding a pair of pupils, specification of a point between the eyes
	S2	Calculation of the characteristic quantity at the specified point
	S3	Extraction of a skin color area
	S4	Calculation of the average value (Rskin) of the chromaticity of the red color in the skin color area
	S5	Designation of an area circumscribing the skin color area
	S6	Division into small areas
	S7	Selection of pupil candidate areas
	S8	Extraction of red-eye pixels
	S9	Correction of red-eye pixels

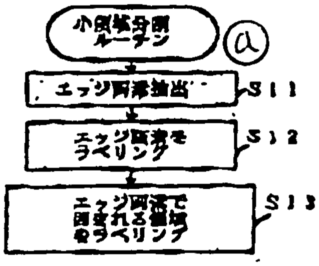

小領域分割
ルーチン
a
エッジ画素抽出
S11
エッジ画素を
ラベリング
S12
エッジ画素で
囲まれる領域
をラベリング
S13

Figure 4

Key:	a	Routine for division into small areas
	S11	Extraction of edge pixels
	S12	Labeling of edge pixels
	S13	Labeling of the area surrounded by the edge pixels

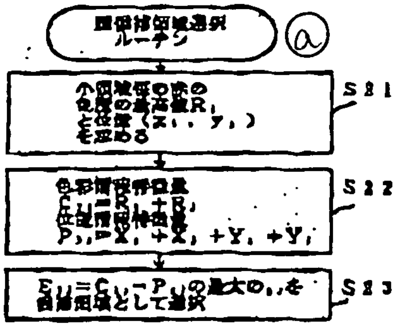


Figure 5

Key:	a	Routine for selection of pupil candidate areas
	S21	The maximum value (R_i) of the chromaticity of the red color over the areas and the position (X_i, Y_i) are obtained.
	S22	Characteristic quantity of color data $C_{12} = R_1 + R_2$ characteristic quantity of positional data $= X_1 + X_2 + Y_1 + Y_2$ $P_{12} = X_1 + X_2 + Y_1 + Y_2$
	S23	The one highest in $E_{12} = C_{12} - P_{12}$ is selected as a candidate area.

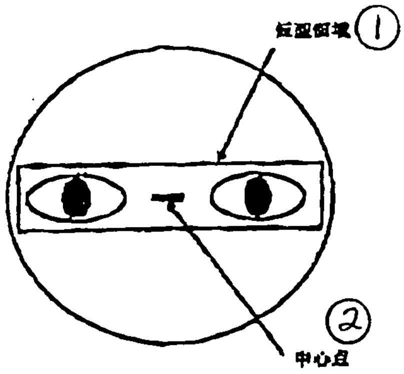


Figure 6

Key: 1 Rectangular area
2 Center point